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RAPID-TRANSIT SUBWAYS IN METROPOLITAN
CITIES.

BY

MILO R. MALTBYE.

FROM THE SMITHSONIAN REPORT FOR 1904, PAGES 759-771.



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RAPID-TRANSIT SUBWAYS IN METROPOLITAN CITIES.^a

By MILO R. MALTBEIE.

The problem of urban transportation is largely one of rapid communication between business and residential districts, and has grown increasingly difficult as population has become more and more concentrated. Street-car companies have tried every conceivable kind of motive power, but they have not been able to keep up with the rapid growth. Steam railroads, which have proved so successful as inter-urban means of communication, have been excluded from most centers because of the noise, smoke, and ugliness of the trains. Horse traction is not sufficiently rapid, and the cable for the same reason has given way to electricity.

However satisfactory surface lines may be for short-distance traffic, their inadequacy to deal with suburban traffic became apparent almost half a century ago in the larger urban centers. The steam roads undertook to solve this question by lowering fares and by greatly increasing the number of trains. London went a step further and built underground roads connecting most of the depots in the metropolis. Other cities, such as New York, Chicago, Boston, Liverpool, and Berlin, have constructed elevated roads, but these are unsightly, and within the last few years they also have proved or are proving inadequate to deal with the vast throngs who daily leave their homes to seek work in other portions of the cities in which they live. And now, as the last resort, electric subways are proposed, and systems have been or are being built in Paris, Budapest, Glasgow, London, Boston, and New York,^b while other cities are considering the question.

^a Reprinted, by permission, from *Municipal Affairs*, New York, Vol. IV, No. 3, September, 1900, whole No. 15, pp. 458-480.

^b Short sections of Berlin's elevated road are underground, but it has not been included in this article because so small a portion will be below the street level.

RAPID TRANSIT IN LONDON.

Owing to the enormous cost of constructing underground roads, a large daily traffic is essential to successful operation. This condition appeared first in London. When railroads were invented and their utility generally recognized, London was already a city of considerable size (population in 1851, 2,363,274). Its ancient streets were considered too sacred to be polluted by a noisy monster, and the importance of rapid communication between the central portion of the city and suburban areas was not yet recognized. Thus the first steam railroads were halted at the threshold of the inner city and made to build their terminal stations some distance from the center of commercial activity. With the growth of the city and the giving over of certain portions almost exclusively to business, some means of com-

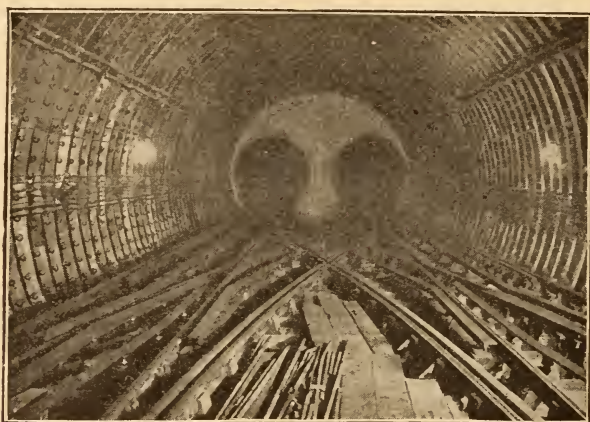


FIG. 1.—The Central London tunnel.

munication between the various depots became necessary. Steam surface roads were out of the question; electricity and cable traction had not been invented, and horse cars were too slow. Underground steam roads seemed the only alternative.

For years the construction of these lines went on, until at present there are 300 miles and upward of 270 stations within a 6-mile radius of Charing Cross. These railways probably carry over 300,000,000 passengers annually, and, including the omnibus, tramway, cab, and steamer passengers, the total approaches very nearly to 1,000,000,000 persons annually.

The unpleasant features of travel in the "underground"—the dingy entrances, the dark tunnels, the dirty, crowded, and dimly lighted cars, the sulphurous fumes from the engines, the dirt-laden air—were appreciated from the start and grew worse as the traffic increased. The lines were mostly near the surface, and openings were provided at short intervals to permit the smoke, steam, and

gas to escape, but they very inadequately performed that function. The managers, with the characteristic English slowness to adopt new methods and the desire to make large profits, reminding one of the New York Manhattan Elevated Railroad Company, refused to adopt electric traction, and until 1890 there was no method of rapid transportation in London other than the steam roads.

In that year the City and South London Electric Railway was opened, about $3\frac{1}{2}$ miles in extent, extending from near the monument, in King William street, only a few blocks from the commercial center of the metropolis, to the suburban district of Stockwell, upon the south side of the Thames. The success of this road and the desire for access to the heart of the city led the Southwestern Railway—one of the most important English roads—to construct a short electric line between its Waterloo station and the Mansion House, opposite the Bank of England. This line is very short, only $1\frac{1}{2}$ miles in length, but it does assist in solving the problem of urban transportation in that it brings the suburban districts reached by the Southwestern into closer communication with the business portion of the city.

The Central London Railroad, the latest, largest, and best equipped of all London subways, most nearly resembles, from the point of location, the New York subway. It runs from the Bank of England, under Cheapside, Newgate, Holborn Viaduct, and Oxford street, past St. Paul's Cathedral, Hyde Park, and Kensington Gardens to a station in the suburban district of Shepherd's Bush, a total distance of $6\frac{1}{2}$ miles. There is a large traffic toward the Bank of England in the morning and to the West End in the evening, and the only means of transportation until lately was by omnibus or carriage or a roundabout route via the underground. No tramway has been permitted to occupy this main artery, and the new underground road will greatly add to the transportation facilities of London.

Various other electric underground lines have been proposed, and within the near future the Metropolitan and the Metropolitan District railways, now operated by steam, will adopt electricity as a motive power. Bids and plans have already been called for.

CONDITIONS IN BUDAPEST.

After London, Budapest was the first city to build a subway. Here it was the outcome of various plans for joining the central and business portion of the city with the park, a favorite rendezvous some $2\frac{1}{2}$ miles distant. Nothing definite was proposed until the spacious and handsome Andrassystrasse was laid out, which offered a direct and attractive route for a street railway. Application was made for permission to build a horse-car line, but the plan met with strong

opposition chiefly upon aesthetic grounds. Several years later, after a short experimental electric line had proved a success, the scheme was again resurrected, electricity being the motive power. This proposal met a fate similar to its predecessors and led to the construction of the subway. In 1894 the concession was granted, and two years later the line was opened to the public. No other project is at present being considered; the transportation problem is not so serious as elsewhere, and the tramway system is very efficient, giving satisfactory service.

THE GLASGOW SUBWAY.

The Glasgow subway was started several years before that in Budapest, but being much larger in scope and more difficult to construct, owing to the great amount of tunneling necessary, it was not opened until the latter part of 1896. Even then it did not remain open, for the traffic was so much heavier than anticipated that it was necessary to close the line for a few weeks and improve the facilities for handling crowds.

The first definite project for an underground road culminated in 1887, when a bill was introduced into Parliament to authorize such an undertaking. The local authorities opposed it, because they feared that tunnels under the Clyde would render any further deepening of the river impossible and thus seriously interfere with the commercial development of the city. However, in 1890, a bill was passed; these objections did not seem of sufficient importance to counterbalance the need for rapid transit. Short sections of the steam roads, similar to those in London, had been operated for some time below the surface, but they reached only a few suburban districts. The new subway connects the business portions of the city with the residential areas to the west and northwest. Its eastern extremity is in the heart of the city, from whence the line makes a broad swing to the west, some 7 miles in circumference.

As yet there seems to be no competition between the subway and the municipal street railways. The latter do not reach many of the suburbs served by the subway, and the long-distance traffic does not use the surface lines because they are slower. Even with the proposed extensions, there will be abundant traffic for each system.

BOSTON'S SUBWAYS.

The Boston subway was opened in 1898. It is entirely unlike every other line, not being a separate and distinct system, but merely affording to the surface lines a means of reaching the business districts without using the surface of the streets. Prior to its construction the street car lines from the many suburban districts around Boston all met on Huntington avenue, Tremont and Boylston streets, or at Scollay square. Between Scollay square and the junc-

tion of Tremont and Boylston streets the congestion was so great that traffic was almost wholly impeded during the busiest hours of the day. Various solutions of the problem were proposed from time to time. An elevated road was rejected by a popular vote, and the proposed widening of the streets involved so great an expense as to be impracticable. The only comprehensive scheme seemed to be a subway in the congested district, and in 1894 an act was passed authorizing its construction. The results have been most satisfactory. The streets are not nearly so crowded as before, and there is a great saving to the passengers of the time necessary to reach the central portion of the city from almost any suburb. The total length of the subway is $1\frac{2}{3}$ miles, and contains over 5 miles of track. Several additional lines are under consideration.

THE COMPREHENSIVE SCHEME FOR PARIS.

The problem of rapid transit was first agitated in Paris almost half a century ago, and as early as 1870 the municipal authorities began seriously to study various solutions. In imitation of other



FIG. 2.—Map of Paris, showing subways in operation and under construction.

cities an elevated road was proposed during the eighties, but the esthetic Parisian would have none of it. The beautiful boulevards, streets, and public places, laid out by Baron Haussman at great

expense, must be preserved at every cost. And true to French custom no plan would be approved until a comprehensive scheme for the whole city was formulated. This had been accomplished by 1896, an electric subway having been decided upon. The street traffic had become so congested that no more surface lines or omnibus routes could be added.

The extent of the Paris metropolitan subway is indicated by the above map. When it is entirely completed the system will be nearly 40½ miles in length, will cost the city \$36,000,000, and the operating company about \$10,000,000 more for equipment.^a At present, only one section and parts of two others have been completely constructed and put in operation, namely, the line running from the Vincennes gate in the east, past the Hotel de Ville, the Louvre, and the Tuileries, down the Champs Elysees to the Place de l'Etoile, from which three lines operate—one to the Trocadero, one to Porte Dauphine, and one to Porte Maillot. The total length is some 8 miles, and the cost about \$7,000,000 for construction alone.

PUBLIC CONTROL IN GREAT BRITAIN.

The relation of the municipality to the subways varies greatly from city to city. In no instance have the city authorities undertaken operation, but in Paris and Boston, as in New York, the public owns the subway, having constructed it at public expense.

The extent of public control is least in Great Britain, there being a marked difference between street railways—surface lines—and underground roads. The former are subject to strict control, and the municipality may take over a line twenty-one years from the time when the franchise is granted, or may construct or purchase the tracks and rent them to a private company. But no underground road is municipally owned or operated, and no public authority has the right under the act granting the franchise to purchase a line. Of course the local authorities may regulate to a moderate degree, but beyond a somewhat restricted exercise of the police powers they may not go. The most important provision found in any of the acts, except clauses protecting avowedly private interests, such as are to be found in acts creating steam railroads using private property principally,^b is one requiring workmen's trains to be run each day, morn-

^a The city has planned for two more sections, making eight in all, bringing the total length up to 48.5 miles, and the cost up to between \$45,000,000 and \$50,000,000. These last two sections have not yet been authorized by the central government.

^b The restrictions imposed upon private companies relate principally to the amount of capital that may be issued, the extent to which loans may be negotiated, location of the road, the property purchased, the indemnities paid, the maximum fares charged, the number of trains run, the motive power used, etc.

ing and evening, at a fare not to exceed 2 cents for the whole or any part of the journey on the Central London Railway. Of course Parliament knows no higher law than its own will, and may impose any restrictions or may order compulsory purchase at any price, but all such proceedings are without the realm of probability.

This difference between underground and tramway lines rather surprises one at first, for British cities have gone as far in the direction of municipal socialism as those of almost any other country. The explanation is a very important fact, viz, that municipalization in Great Britain is not so much an economic movement as the expression of the desire that the local governments keep control of the streets. The underground roads, in so far as they cross or pass under the streets and public places, are using public property, to which the



FIG. 3.—A station on the Central London Railway.

public authorities have as clear a title as that of a private individual to the ground under his house. The law knows no limit either above or below the surface. Yet no demand has been made upon the underground lines for payment or for the reservation of the right to take over the line. It is to be borne in mind, however, that the underground roads, especially those constructed since the movement for municipalization became strong, are some distance below the surface,^a that their construction and operation necessitates very little disturbance of the street surface, and that instead of increasing the street traffic they relieve it. Further, they do not promise to be exceedingly remunerative, and without public aid either through subsidies or free grants to use the ground below the surface of the streets many of

^a The average depth of the Glasgow subway is 29 feet, and the Central London Railway is everywhere, except at the western terminus, which is on private property, at least 30 feet below the surface of the streets. Only the Metropolitan and the Metropolitan District Company are near the surface and have open subways. These are the steam roads, which got their powers years ago,

them would not have been built. Both London and Glasgow have recognized these facts, and have not opposed the companies when they have appealed to Parliament for power to use the ground below the streets.

FRANCHISE IN BUDAPEST.

The nearest approach to British conditions is to be found in Budapest. There the city has invested nothing; the subway has been built, equipped, and operated by a private company. But the city has reserved the privilege of taking over the line in 1940, when the concessions for the surface lines expire, provided announcement is made of its intention two years previous. Otherwise the franchise runs ninety years from 1896, or until 1986. The maximum fare is fixed at 10 kreutzers (5 cents) during the first fifteen years, after which the city authorities may require a reduction. The city will receive from the gross revenues an amount to be calculated on the following scale:

	Per cent.
During the first ten years following a period of twenty years, 1916-1926---	1
During the second ten years following a period of twenty years, 1926-1936_	2
During the third ten years following a period of twenty years, 1936-1946__	3
During the fourth ten years following a period of twenty years, 1946-1956_	4
From this time to the end of the concession, 1956-1986-----	5

During the first twenty-five years the city can not grant any other concession for the establishment of a system of transportation of any kind between the center of the city and the park. And for the first fifteen years the company is exempt from taxation. The city, of course, possesses in addition the usual police powers, and the concession contains many provisions specifying how the subway was to be built and how it is to be operated.

TERMS OF THE PARIS CONCESSION.

The position of the Paris subway is the result of many compromises between the municipal council and the central government whose approval was necessary for the execution of the project. The central authorities insisted that the subway be connected with the railroads in order that trains from the country might be run right through to the center of the city and a suburban traffic thus developed. The municipality feared that the railroad companies would get control of the subway and that a large portion of the population would be induced to leave the city and live in the suburbs, thereby decreasing the city's revenue from octroi. A compromise was finally effected, and in the early part of 1898 the act was passed, which fixed the gauge of the road, over which there had been so much dispute, at the standard width. But the city, in order to prevent the railroads from ever sending their cars over the subway, has built

the tunnels so narrow that only those cars can be used that are especially constructed for the subway.

Another point upon which the municipal council and the central government did not agree was as to who should operate the lines. The council wished not only to own but to operate the road. The central authorities objected, but finally compromised upon municipal ownership and private operation. This plan offers many advantages. According to a general law passed in 1842, a private company gets a franchise for seventy-five years if it builds a railroad; but if a public authority constructs a line it may shorten the period to thirty-five years. Further, under private ownership, a company would find considerable difficulty in raising sufficient capital to build and operate the whole system. Paris could borrow the money easily, and not only easily, but at a lower rate of interest than a private company. This saving would be no small factor and will enable the road to lower fares ultimately.

The contract between the municipality and the operating company is most interesting. The franchise runs for thirty-five years, but at any time within seven years from date of construction the city may acquire the lines. The company agrees to maintain the highest degree of efficiency, to give to its employees an annual vacation of ten days with full salary, to give them full pay during military instruction and sickness, to insure them against accident, and to pay the city 2 cents for every first-class ticket and 1 cent for every second-class ticket sold, with the added provision that when the annual passenger traffic exceeds 140,000,000 persons, this sum shall be increased, reaching at the highest mark 2.1 cents for each first-class and 1.1 cents for each second-class ticket. As the concession fixes the rate for a first-class ticket at 5 cents and for a second-class ticket at 3 cents, and for school children with teacher at a uniform rate of 1 cent, about one-third of the entire receipts will go to the municipality and two-thirds to the company. As the cost will be about \$35,000,000 for the lines thus far authorized, an annual revenue of \$1,100,000 will be necessary to pay the interest, sinking-fund charges, and incidental expenses; operating expenses are paid by the company leasing the subway. Thus, if the entire system should carry only 125,000,000 passengers annually, the city would more than pay all expenses. As this is considered a very low estimate and as it seems almost certain that the traffic will far exceed this number, the city will probably find the subway a paying investment. The roads in London, Berlin, and New York carry nearly 5,000,000 passengers per mile per year; the Paris subway ought easily to reach the necessary 3,000,000 per mile per year.

The entire system of subways is not to be constructed at once, but is to be divided into six sections (two more have not been approved by

the central government), which are to be opened from time to time as specified in the act, until by 1916 every line will be in operation. All are to be operated by the present leasing company and upon the same terms as given above. The thirty-five-year period—the duration of the franchise—is to run from the date of opening each line, and to prevent any inconvenience which might arise from franchises for different sections falling in at different dates, the concession provides that the company may retain possession of all until the termination of the last franchise, and shall pay 45,000 francs per kilometer per year (\$14,000 per mile) for every line whose lease expires previous to that time.

CONDITIONS IN BOSTON LEASE.

Like Paris, Boston owns its subway and has rented it for twenty years to a private company—the West End Elevated Railway Company, which has subleased it to the Boston Elevated Railway Company. The rental will never be less than $4\frac{1}{8}$ per cent of the cost of the subway, and if this sum does not amount to 5 cents for each car using the subway, it shall be made up to this sum. The income will pay the interest on all outstanding bonds and provide a sinking fund to extinguish them at maturity—forty years hence. All operating expenses are paid by the operating company, and at the expiration of the lease the city will pay the fair value of all rails, pipes, wires, etc., which are affixed to the subway.

COMPENSATION.

Comparing the various methods of securing compensation, it is evident that in no instance have large profits been secured. Budapest undoubtedly receives the most, considering the fact that it has invested nothing, for even the expense of rearranging sewers, water mains, conduits, etc., was borne by the subway company. Paris may make the most, for if the traffic greatly exceeds 125,000,000 persons annually, the net profit will be more than 5 per cent of the gross receipts, as the rate is about 33 per cent of the gross receipts. However, if the traffic should fall considerably below this figure, the municipality will need to make up the deficit from other sources. There seems to be little risk in this direction, and Paris has followed its usual course of exacting large payments from municipal monopolies rather than of requiring lower prices and increasingly better service. London and Glasgow are at the other extreme, and New York and Boston are not far distant, for the payments are not large, barely exceeding for the present the interest on bonds issued for the construction of the subways and sinking fund charges to wipe out the debt.

Considerable variety exists also as to the basis for compensation. Budapest uses gross receipts—an easily ascertainable basis and freed

from much adverse criticism by the requirement that the rate increase as the years pass, or, in other words, as the road becomes more remunerative. Paris has adopted an even simpler basis, receiving a certain fixed sum for each ticket sold. An attempt has also been made to vary the amount with the traffic, but not quite so successfully as in Budapest. In Boston and New York the cost of construction is used as a basis, and the payment to the city is a fixed sum, no matter what the profit or the loss to the private company or the size of the traffic.

MOTIVE POWERS.

An examination of the roads themselves reveals a great difference between those recently constructed and the underground lines in London built many years ago. Steam as a motive power has given way to electricity. Every London line constructed since 1890—the date when the City and South London road was opened—has adopted the third-rail electric system, as have also Paris and New York. The Budapest and Boston subways use the overhead trolley. Glasgow clings to cable traction, which is largely accounted for by the conservatism of the Scotch and the fact that in 1890, when the work was begun on the subway, electricity had not yet clearly demonstrated its efficiency. Cable traction was much cheaper, and upon the steep grades the car going down will help to pull up the car going in the opposite direction. The act of Parliament imposes no conditions except that steam can not be used. The Glasgow subway is unique, in that it is the only underground cable railway for passengers in the world. Thus far it has worked very well.

TRAVEL A PLEASURE.

All the modern subways, even that of Glasgow, have adopted electric lighting, and the cars and tunnels are in marked contrast to those of the steam lines in London, which are dimly lighted, dirty, and forbidding. Glazed tiles have generally been used, especially at the stations, and in every way the comfort and pleasure of the passengers have been administered to. The entrances in Boston and Budapest particularly are very artistic, and instead of being repellant, because of their dirt and ugliness, even add to the beauty of the streets and public places in which they are located. The London electric lines, being situated many feet below the level of the streets, have provided spacious elevators, which counteract the disadvantages of deep-level travel. The Paris, Budapest, and Boston subways do not need them, being located near the surface of the streets. The Glasgow company has one, in Kelvinbridge, where the road is 115 feet below the crest of the hill, and New York will have a few where the road is far below the surface.

In the construction of the subways, plans much the same have been followed everywhere. Where the road level is near the street level, an open ditch was made, steel framework inserted, and the street pavement replaced. Where this was impracticable, tunnels were driven; and in a few instances short viaducts were erected. The Budapest subway is everywhere just below the street level, and consists of two parallel lines at the same level, separated only by steel pillars, station platforms, or thin walls. The Paris subway likewise consists of two parallel lines and always at the same level, except where one section crosses another and a dip is made to avoid crossing at grade. Some of the distance the lines run side by side in a single tunnel; in other portions each line has a separate tunnel, uniting only at stations. The Glasgow road consists of two distinct tunnels throughout, except at stations, as is true of nearly all the London electric lines except the Waterloo and City road, which has only one line almost all the way. The Boston subway has from two to four lines, usually at the same



FIG. 4.—Budapest stations.

level, except where it is necessary to raise or lower one to avoid grade crossings. The New York line is the only one that has tracks for the special purpose of running express trains; and with the Central London road is unique in raising its stations above the level of the road. Each train on its departure thus is accelerated by the force of gravity, and as it approaches is checked by the same force. This will greatly increase the rate of speed by reducing the time required for stopping and starting.

Most of the modern subways are adopting the American style of car, with an entrance at each end, in place of the old-style compartment coach. Even the London roads are making the change, and the Glasgow line introduced them at the start. The Paris car is a hybrid, having two doors on each side, one set being used for entrance and the other for exit. The train idea seems also to be spreading, as being more economical and better adapted to handling large crowds.

There is one marked difference between foreign and American lines. Most of the former have first and second-class compartments or cars; the latter charge the same fare for every one. The Glasgow subway maintains only one service and the tendency elsewhere is in this direction. Some London roads have already made the change.

The uniform fare, regardless of distance, is also more common with us than abroad. In Paris and Budapest it is in vogue, but the lines are so short as to render a graded system unnecessary. The Glasgow company intended to adopt it, but as the cars run continuously around the circle, one would be able to ride indefinitely for one fare. To prevent this, a zone system was adopted. A penny ticket (2 cents) allows one to go as far as the fourth station from where he enters the car, or about $1\frac{1}{2}$ miles—one-fourth the circumference



FIG. 5.—A Central London Railway car.

of the road. A 2-penny ticket (4 cents) entitles one to travel any distance, but not more than once around the circle. A ticket is given each passenger, which he gives up upon leaving the station at his destination. Any one who has ridden farther than his ticket indicates is thus found out and required to pay.

That the subways of London, Paris, Budapest, Glasgow, and Boston were needed and are performing a useful social service is shown by the large number of passengers carried. Their influence can only partially be estimated, but undoubtedly the effect upon social conditions, especially housing and overcrowding, is considerable, not to mention the saving of time in going to and from work. Doubtless rapid transit will not solve either the housing problem or transform our cities into Utopias, but it will alleviate social conditions and prevent what otherwise would be unbearable evils.

